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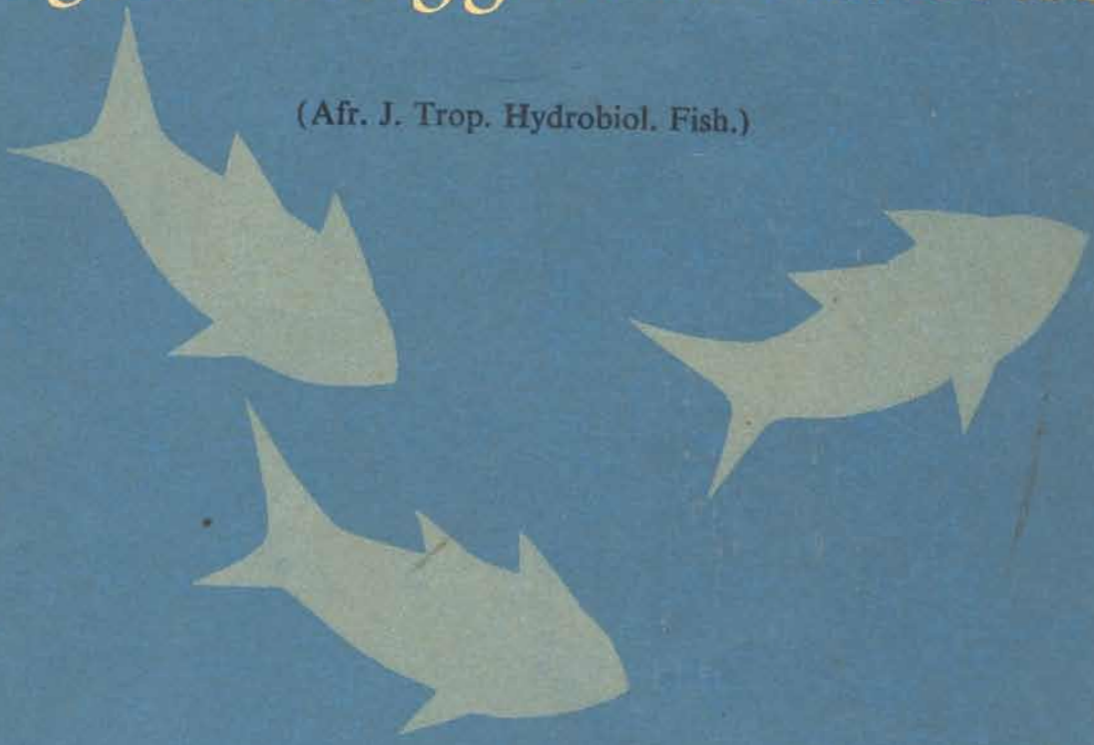

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SOME MAJOR UNSOLVED ASPECTS OF THE DYNAMICS OF AFRICAN FISHERIES AS RELATED TO QUESTIONS OF RATIONAL DEVELOPMENT AND MANAGEMENT

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HISTORICAL BACKGROUND

Historically biological investigations of the fisheries resources of the African continent can be sub-divided into four bio-political time phases:

The Colonial Era (1896-1950)

During this period fisheries expeditions in Africa attempted for the first time to collect, identify and establish the taxonomic characteristics of some of the African fishes. While only a few of these workers actually took part in these expeditions, most were situated in museums or universities in Europe, and rarely, if ever, saw living specimens of the material they handled, which explains some of the more apparent taxonomic inconsistencies of the period. Howbeit the classical reference works of some of these workers as catalogued in THYS VAN DEN AUDENAERDE (1968) have remained ever since the foundation on which subsequent investigations on African fish and fisheries have been built.

The Period of Ecological Investigations (1950-1965)

This period marked the intensification of "academic" investigations into the ecological characteristics of the African freshwater ichthyofauna although description and classification of new species continued alongside the investigations of their life histories. The chief contributors in this era were either "free-lance" expatriate biologists or the expatriate colonial civil servants. The East African Freshwater Fisheries Research Organization at Jinja (EAFFRO) and many of the Fisheries Departments in the different countries provided comfort and facilities to the majority of this breed of fisheries biologist. During this period a slight consciousness emerged of the need to institute some management guidelines to curb the overfishing of some waters. However, the biological data thus far collected were either inadequate on a time basis or inapplicable for use as fisheries management tools, the reason being that in some cases the zeal for academic excellence and innovation overshadowed the need to orientate the designs of the research programmes to the conservation of the fisheries resources, which were at that time beginning to undergo sustained and heavy exploitation, albeit on a very irrational basis.

Development Period (1965-1975)

The period has been marked not only by the intensification of studies aimed at deter-

mining further aspects of the ecology of the African fishes, but by greater emphasis on biological and other related investigations geared to the management and development of the African Freshwater Fisheries. The financial backbone and technical impetus and expertise for this phase have been provided by the UNDP (United Nations Development Programme)—which presently supports projects in many of the important natural and man-made lakes in Africa.

Through the UNDP projects has evolved for the first time the creation of research teams composed of international experts and their African counterparts engaged in stock assessment and resources evaluation in the commercially important African freshwater fisheries. The achievements so far of this special internation financial assistance and scientific co-operation were evident at the last two annual UNDP Stock Assessment Seminars held in Jinja and Bujumbura (REGIER 1971).

The Period of Mechanized Commercial Exploitation (1975-)

This period represents the logical extension of period 3 with which there will be considerable overlapping. Whereas in periods 2 and 3 work has been and is being done on the ecology of African fish, and in some instances on aspects of their population dynamics, there remain certain other uninvestigated areas whose understanding are essential to a continuous appraisal of the abundance and population structure of the stocks in relation to the impact of mechanized or other improved methods of exploitation. This paper attempts to put in perspective some of these unsolved aspects for the consideration of the delegates.

POPULATION STRUCTURE

At present the greatest potential for the development of lucrative commercial freshwater fisheries in Africa exists in two of its largest inland lakes, Victoria and Tanganyika. Attention is, therefore, drawn to the need for a more concise investigation of the population dynamics of the economically important and dominant fish stocks in these lakes in order to provide guidelines for similar studies on the developing or dwindling fisheries of man-made lakes in Africa and elsewhere.

Lake Victoria

The EAFFRO stock assessment biologists have carried out full-scale exploratory bottom and mid-water trawling in Lake Victoria since January, 1969. Preliminary results indicate the preponderance of the *Haplochromis* species-flock over the other available fish stocks. They constitute at least 80% of the demersal ichthyomass with an estimated minimum standing stock of 550,000 metric tons (BERGSTRAND AND CORDONE 1971; KUDHONGANIA AND CORDONE, unpublished).

Only about 90 species of this genus have been described out of an estimated 200 component species. The Lake Victoria *Haplochromis* are under-exploited by the traditional gillnet fishery. On account of their abundance and unique ecological adaptation to the various habitats within the Lake Victoria ecosystem, the development of commercial fishery in Lake Victoria should be geared primarily to the rational exploitation of this resource.

It has been estimated (KUDHONGANIA AND CORDONE, unpublished) that the potential yield of catches (4.5-5.0 cm total length, using 19 and 38 mm codend mesh size) *Haplochromis* stands at 200,000 metric tons. A fleet of 15 trawlers (each of 12 m in overall length) is to go into operation shortly as part of Phase II of the UNDP project to test the economic viability of a mechanized trawl fishery on the lake. It has been estimated that each trawler should catch at least 500 tons of fish per annum to justify

the erection of the infrastructure necessary to support this operation.

Hitherto only a fraction of the total number of the *Haplochromis* species has been described, but the diversity in coloration and morphology encountered within the genus indicates that the taxonomy and systematics of its component species remain a challenge to field biologists.

Closely related to the lack of taxonomic identification of the majority of the species is the total absence of any knowledge of the bionomics and life history of these species and especially their ecological inter- and intra-relationships with the other fish stocks in the aquatic environment. It is pertinent, therefore, that such population parameters as size and age groups, growth rates, feeding rates, natality, rate of recruitment and mortality coefficients be established for the component species to enable projections to be made on the impact of a future efficient and intensive highly mechanized exploitation on this unique assemblage of fish stocks.

Since the trawl fishery in Lake Victoria will be slanted in favour of optimum harvesting of *Haplochromis* stock, any comprehensive information on the biology of these species would enable a model to be worked out to facilitate the continuous monitoring of the effect of this skewed exploitation of the *Haplochromis* species on the equilibrium of the population dynamics of the other fish stocks. Indications are that the *Haplochromis* species cannot be exploited in isolation given the mechanics of the fishing gear.

Lake Tanganyika

Both Lakes Victoria and Tanganyika support a large reservoir of commercial fish stocks. Here the similarity ends. In Lake Tanganyika mechanized exploitation with pursue seine of the distinct pelagic fish population *(Stolothrissa tanganicae,* Regan; and *Limnothrissa miodon,* Blgr.) started at the north end of the lake (Burundi) in 1958, and at the south end (Zambia) in 1962 (COLLART 1958; COULTER 1963).

Secondly, some information is available on the changes within the populations of these fish stocks as a result of exploitation in the Zambia region, and there are also published notes on certain aspects of their life histories (MATTHES 1967; COULTER 1970; ELLIS 1971). Complementary studies on the ecology with emphasis on the breeding biology of these species should now be instituted in the northern sector, not only to be used as tools for the rational management of these important fisheries, but also to ascertain what similarities exist in the ecology of these species at the extremities of the lake.

In spite of the political complexities in this region, it is expedient that, through a common ecological approach, a uniform management policy is evolved throughout the whole lake system for the conservation of these important fish stocks. A programme of stock assessment similar to that in Lake Victoria should receive a first order priority so as to monitor and predict changes in the standing crop under varying stresses of mechanized exploitation.

Fish behaviour

On a subsistence level, the single group of fish acknowledged as being of the most economic importance is the *Tilapia* and this is truer of Lake Victoria than possibly anywhere else in Africa. Stacks of scientific papers abound on the biology of *Tilapia* species (THYS VAN DEN AUDENAERDE 1968) and specifically for Lake Victoria, in the archives of EAFFRO (EAFFRO Annual Reports).

Over recent years there has been a steady decline in the numbers of these fish caught per net in the traditional gillnet fishery. Overfishing and laxity in enforcement of some of the inadequate and sometimes inappropriate management regulations, have

been given as contributing to this decline.

However, another school of thought is convinced that lack of precise knowledge of the behavioural tendencies of the *Tilapia* species especially in relation to their schooling and migratory traits might explain why biologists on Lake Victoria have been unable to offer predictions as to when and where better catches of this fish stock can be encountered on the lakes. It will be in the public interest if biologists are able to give these forecasts.

As a step in this direction emphasis should now be rechannelled into the study of their diel vertical and spatial movement especially with regard to any lunar and seasonal variations on a lake-wide basis. A massive tagging and marking programme with adequate safeguards for recoveries should receive serious consideration. A knowledge of the migratory and schooling behaviour of the *Tilapia* species by biologists and fisheries administrators could be used as a most effective weapon in the regulation of fishing activity, and ultimately in the conservation of this valuable fisheries resource.

Effect of hydroelectric projects on the ecology of some freshwater fish

Experience so far gained from ecological and other fisheries-orientated studies in African man-made lake (LOWE-McCONNELL 1966; OBENG 1969) has tended to emphasize the need for comprehensive pre-impoundment biological studies in river systems earmarked for hydroelectric projects. Such studies would enable the synthesis of ecological and energy-transfer models that could be used to predict or adequately interpret the development sequence of the "lacustrine" fish populations with the newly formed reservoir.

We have to avoid the situation in which the exploitation of the fish stock in the newly created reservoirs is allowed to increase indiscriminately during the initial rise in productivity of the reservoir. This is disastrous especially in situations where this high fishing effort is sustained through the stabilization phase of the reservoir and the upward trend remains unregulated even when there is a marked overall decline in the catch per unit effort.

Based on pre-impoundment studies and experiences accrued from other ecologically stabilized reservoirs, the ultimate goal of the fish biologist and others involved in resource management should be the ability to predict what level of exploitation can be tolerated right from the initial filling of the reservoir such that the productive life (in terms of basic productivity and yield of fish) of the reservoir can be extended beyond what would otherwise be the case. This presupposes the prediction at initial impoundment of the potential yield of the reservoir at its maximum equilibrium state.

On the basis of the concept enunciated above all the African man-made lakes now in operation are past saving. However, the fisheries resources in the new hydroelectric projects now in development stages in Africa are not past redemption. The construction of a dam according to LAEVASTU (1965) may:

(i) cause a physical barrier to upward or downward migration of fish,
(ii) cause damage to stream fisheries above or below the dam,
(iii) reduce or increase breeding and feeding areas, and generally could alter the limnological characteristics of the whole aquatic system. The effect of two new hydroelectric projects now on the planning board should be considered against this background.

The Kidatu Hydroelectric Project of the Great Ruaha River (one of the most important rivers of Tanzania) is situated about 136 km from Morogoro. The dam is likely to interfere with the upward migration of young eels for feeding and of *Labeo* and

Barbus during their breeding season. These three species form an important part of the subsistence fishery in this river system. It has been observed that the barrages on the Tana River (Kenya) have had adverse effect upon the migratory species: *Labeo, Barbus* and *Anguilla.*

It, therefore, seems relevant that studies should be initiated to ensure that adequate safeguards are incorporated into this new dam to alleviate any deleterious effect which the physical blockage of the river system would have on the spawning behaviour of these fishes. Fish passes, ladders, physical transfer of fecund and juvenile fishes over the barriers and provision of an artificial spawning and nursery grounds are some of the biological options available. These have become standard practice in hydroelectric projects in continental Europe and the Americas. BALON (1971) showed that in Lake Kariba elvers managed to pass into the lake through openings in the dam.

The second scheme also in Tanzania is the multi-purpose Kishanda Valley Project aimed at the development of the Kagera River basin. The project aims at diverting Kagera River water through the Kishanda Valley, thereby creating a double waterway and control on the river. After inundation the dam will create a water spread of 250 kms^2; a waterway of 200 km and a total of 500 km shoreline. This will drain about 1,000 km^2 of swamp land (400 km^2 in Rwanda and 600 km^2 in Tanzania).

Since the Kishanda Valley Project does not aim at actually damming the river but only drawing in water from Lake Rushwa (through which it flows) to fill in the Kishanda Valley, a different management approach is called for. Studies should be instituted to test the desirability of restocking in the inundated valley those species of fish which are likely to adapt and repopulate this new waterspread. Already some species of fish which are endemic in the Kagera River system have been suggested, for example, *Labeo victorianus, Barbus, T. nilotica* and *T. melanopleura.*

In connection with these new approaches to the fisheries of the hydroelectric projects in Africa must be emphasized the need to evolve a whole new concept for the conservation of the riverine *Labeo* species which are showing marked diminution in number in their traditional river habitats. Since the lucrative *Labeo* subsistence fishery has been built around the exploitation of fecund fishes on their breeding migration, something has to be done to curb this practice, or alternatively provide for them an escape route to artificial breeding grounds. A breakthrough has just been mooted on the artificial spawning of *Labeo* in ponds at the Sagana Fish Culture Station in Kenya. The significance of this is beyond speculation.

Predator-Prey relationship

The role of predators within African fish populations has been noted by some workers (JACKSON 1961; COULTER 1970). From all the available records the species responsible for the greatest damage to commercial fish stocks have been *Hydrocyon vittatus* Cast. in the African man-made lakes, and those belonging to the family Centropomidae (*Lates mariae* Stdr.; *Lates angustifrons* Belgr.; and *Luciolates stappersii* Blgr.) in Lake Tanganyika.

Recently another species *Micropterus salmoides* (the large-mouth black bass) introduced into Lake Naivasha (Kenya) has been accused of being responsible for the declining *Tilapia* fishery in the lake. The effect of another predator *Lates niloticus* introduced into Lake Victoria has not yet been evaluated.

It should be worthwhile to investigate how the knowledge of the predator-prey relationships in these waters can be used to effectively manage the fisheries in favour of the more desirable fish stocks. Can the

declining more important "food fishes" (prey) be resuscitated by the elimination of the predators along the line indicated in the survey carried out by FROST and KIPLING (1967) in Lake Windermere, England, in which it was indicated that the partial removal of the pike predators appreciably improved the perch fishery?

Parasitism

Parasites occur widely in African freshwater fishes. Requiring urgent attention are those parasites that occur in economically important fishes which in many cases devalue their aesthetic quality and palatability, and generally in the most serious cases lower their economic profitability.

Of significant importance are the nematodes, especially the *Contracaucum* species (possibly *C. spiculigerum* (Rud.) which infect *Tilapia*. What have been thought of as the post-larval and adult forms have been found in abundance in the proventriculus and stomach of aquatic birds, and the larval stages in the pericardial cavity of the *Tilapia* spp. These parasites occur widely in *Tilapia* spp. in the East African lakes of the eastern arm of the Rift Valley. The particular species involved have not been identified as nobody has worked out the life cycle or described the adult forms.

It is therefore considered necessary that an investigation of these parasites should be carried out to establish:

(i) parasitic incidence and intensity in relation to the ecological characteristics of the environment,
(ii) the identity of the causative organisms, their life cycle and their vectors,
(iii) the pathological effects of the parasites (biochemically and physiologically) especially effects on growth rates and reproductive capacity,
(iv) the biological basis for their control with particular reference to the elimination of the intermediate hosts where this measure is economically or politically expedient.

SUMMARY

Studies of fish and fisheries in Africa fall into four phases: the period of fisheries expeditions, ecological investigations, the development phase, and the period of mechanized exploitation. There is need to establish the taxonomic status and ecology of the varied components of the potentially important *Haplochromis* in Lake Victoria. A comprehensive study of their bionomics and life history, population structure, natality, recruitment and mortality coefficients should be undertaken. Emphasis to be laid on the study of the ecology, especially breeding behaviour of the economically important clupeids *(Stolothrissa tanganciae* and *Limnothrissa miodon),* in Lake Tanganyika. A comprehensive investigation into the migratory and shoaling behaviour of the Lake Victoria *Tilapia* to be initiated. Pre-impoundment studies to be undertaken to assess effects of hydroelectric projects of fisheries. Studies on parasites of economically important fishes to be stepped up to assess pathological effects and the biological basis for their control. The role of predators, e.g., *Hydrocyon, Lates* and *Micropterus salmoides* in commercial fish populations should be evaluated, and the knowledge gained used to effectively manage the fisheries in favour of the more desirable fish stocks.

RESUME

Les études sur le poisson et la pêche en Afrique se divisent en quatre stades: la période des expéditions de pêche, celle des investigations écologiques, celle du développement et enfin celle de l'exploitation mécanisée. Il est nécessaire de définir la taxonomic et l'ecologies des divers éléments du genre *Haplochromis,* potentiallement le plus important du lac Victoria. Il est souhaitable d'entreprendre une étude complète de leur

histoire naturelle, structure des populations, coefficients de natalité, recrutement et mortalité. Il faut étudier principalement l'écologie, en particulier le comportement sexuel des clupéidés économiquement importants *(Stolothrissa tanganicae* et *Limnothrissa miodon)* du lac Tanganyika. Une investigation complète sur le comportement migrateur et la formation des bancs de *Tilapia* du lac Victoria doit être effectuée. Des études doivent être entreprises avant la mise en eau, afin de prévoir les effets sur les pêcheries des ouvrages hydro-électriques en projet. Amplifier les études sur les parasites des poissons d'importance économique, afin de déterminer les effets pathologiques et la base biologique pour lutter centre ces parasites. Estimer le rôle des voraces, *Hydrocyon, Lates* et *Micropterus salmoides* dans les populations de poisson d'importance commerciale et utiliser les donnés acquises en vue d'un aménagement efficace des pêcheries par l'amélioration des stocks de poisson.

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